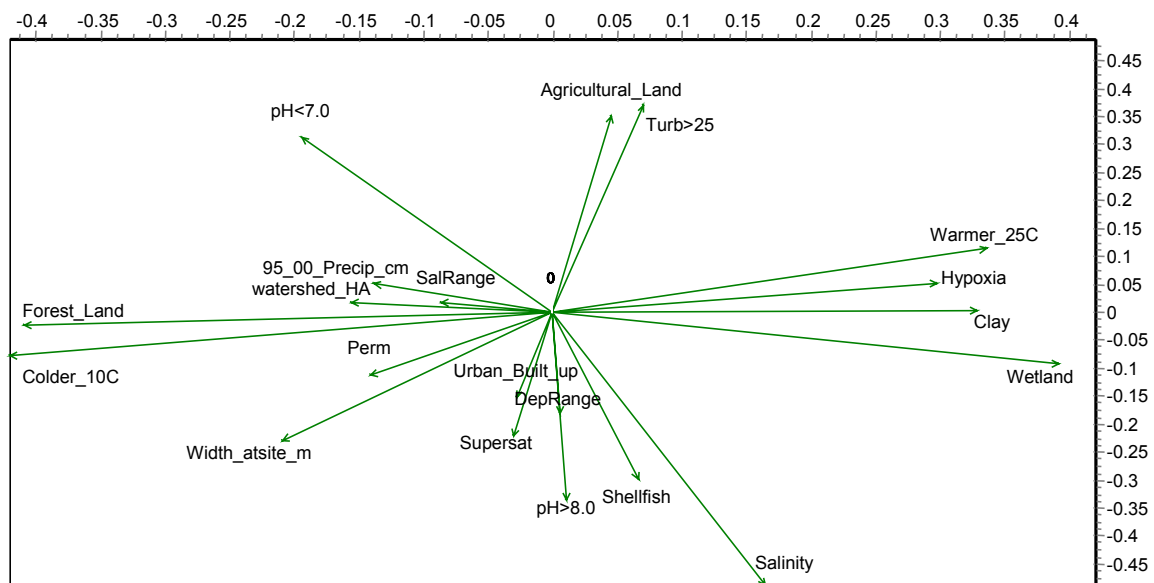**Figure 18**. Relationship between the PC 1(x-axis) & PC 2 (y-axis) and 51 NERR sites.

Figure 19. The relationship between PC 1 (x-axis) & PC 2 (y-axis) and attribute variables.

Figure 20. Major groupings of 51 NERR sites identified by cluster analysis were plotted against the first two PC axes using PCA.

Nonlinear multidimensional scaling using artificial neural networks
More total variance was explained by nonlinear multidimensional scaling compared to PCA with the same numbers of components/dimensions before reaching 20 components (Appendix 34). For example, 13% more variance was explained by the first three components using multidimensional scaling than was explained by the first three components using PCA. This scenario indicated the existence of non-linearity in the relationship among these site attributes. Similar trends of explained variance were generally observed in both PCA and multidimensional scaling; however, ten PCA components were needed to account for more than 85% of total variance, compared to only six multidimensional scaling components to account for similar amounts of variance (Figure 21). Subsequently, the relationships among these variables were complex and were not reducible to lower dimensions as we had hoped, a similar conclusion reached using PCA and cluster analysis.

Fifty-one sites were spatially mapped to the first two dimensions, which was parallel to the method used to examine the pattern of NERR sites using PCA (Figure 22). The distribution pattern of the sites was very similar to the result using PCA, with the reversal of both axes. For instance, the group on the upper right of the PCA map was located on the lower left corner of this new map. Again, the sites with more distinctive features, such as RKBBR, NOCMS, HUDTS, HUDTN, NARTW, and CBVGI, consistently occurred on the edge of the map. The sites with warmer water separated from the others along the first dimension while the second axis differentiated the sites using salinity, turbidity, and percent area of agricultural land. These predominant natural trends were similar to the first two dimensions from the PCA.